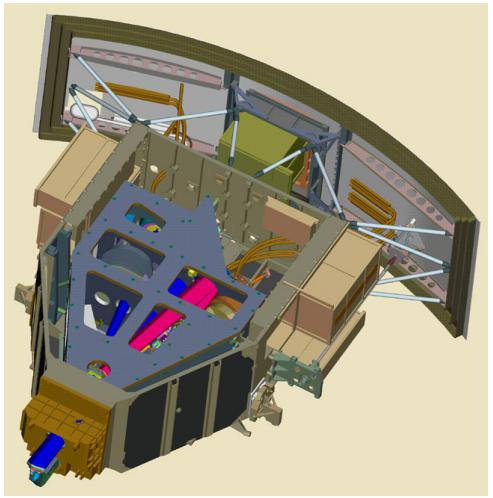
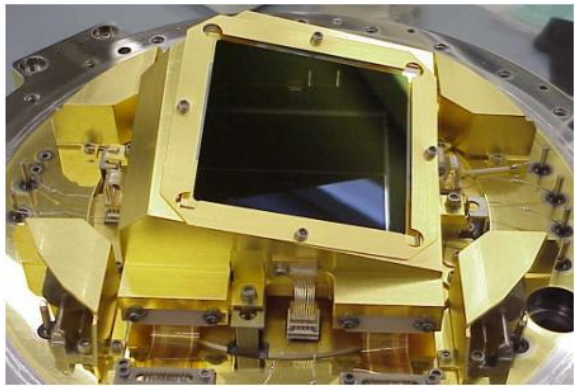
Wide Field Camera 3
Update to Origins Subcommittee

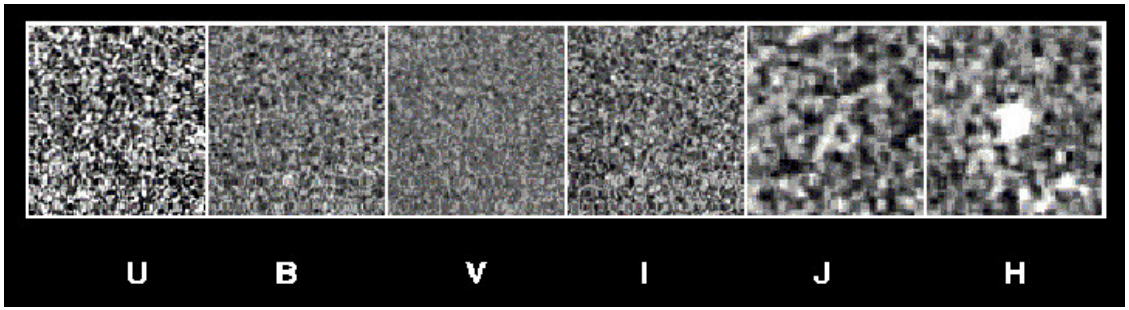


Randy Kimble

Instrument Scientist

December 2, 2002





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WFC3 Status Summary (1)

(Why I'm here.) New instrument scientist appointed upon Ed Cheng's departure from GSFC to form private company.

WFC3 continues to make excellent technical progress:

- Optical bench is fully populated with flight optics/filters (except for pick-off mirror) and mechanisms.
- Optical system has been fully aligned w/surrogate detectors and delivers excellent optical performance.
- Optical bench is being prepped for shipment to GSFC on December 9.
- All flight electronics boxes are complete – many have been delivered to Goddard.

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WFC3 Status Summary (2)

- Modified TECFIRE design is fully qualified and delivers better than required performance for cooling IR channel.
- UVIS flight detector package is complete, incorporating superb Marconi CCDs; now in environmental testing.
- IR detector qual unit successfully completed thermal testing with performance margin.
- IR FPA development has been problematic, but steady progress has been made; ***a flyable device is in hand*** and additional devices are currently in fabrication.
- Optical Stimulus is through thermal-vac and ready to support I&T at Goddard.
- I&T schedule at GSFC has been reworked to accommodate launch delay in the most cost efficient manner.

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Scientific Mandate & Capabilities

- Ensure an imaging capability through 2010
  - Provide complementary capabilities to ACS
  - With several years less radiation damage to CCD detectors
- Panchromatic coverage over a wide field
  - 200 to 1700 nm, widest coverage of any HST instrument
- Uniquely capable in the near-UV
  - 200 to 400 nm
  - Higher NUV "discovery efficiency" (throughput × FOV) than other HST instruments by 15-30×
- Uniquely capable in the near-IR
  - 850 to 1700 nm
  - Higher NIR "discovery efficiency" than NICMOS3 by >10×
- Large and diverse set of filters: 48 UVIS, 16 IR

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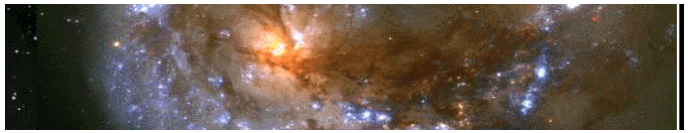
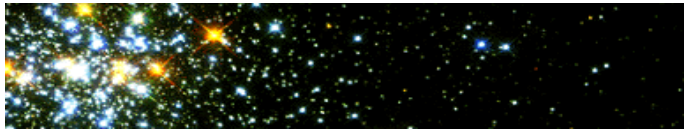
WFC3 Science Themes

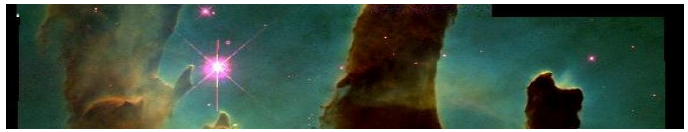
High-z Universe : What were the first luminous objects? How did galaxies assemble?



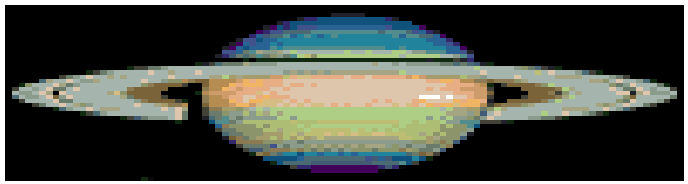
Nearby Galaxies : How universal are the processes of star formation in galaxies?



Resolved Stellar Populations : How old are globular clusters? How much mass is locked into low mass stars?



Stars and Interstellar Medium : How does the star formation rate depend on the environmental conditions?



Solar System : What are the properties of the relic remnants of the early solar system?

These topics are addressed in detail in the WFC3 Science White Paper.

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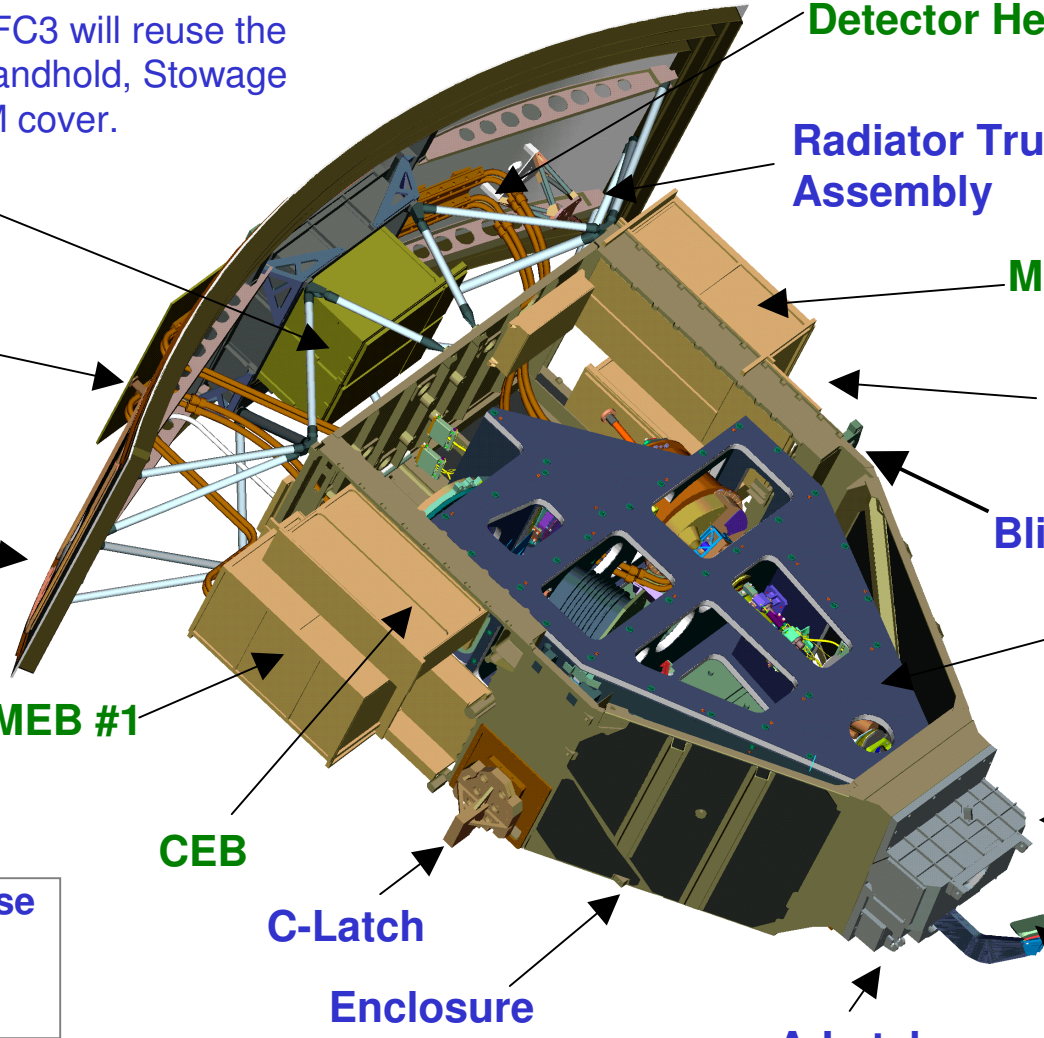
Scientific Oversight Committee

SOC Member	Affiliation
Bruce Balick	University of Washington
Howard Bond	Space Telescope Science Institute
Daniela Calzetti	Space Telescope Science Institute
Marcella Carollo	Columbia University
Michael Disney	University of Wales At Cardiff
Michael Dopita	Institute Of Advanced Studies Mt. Stromlo & Siding Spring Observatory
Donald Hall	University of Hawaii
Jon Holtzman	New Mexico State University
Gerard Luppino	University Of Hawaii
Patrick McCarthy	Carnegie Observatories
Robert O'Connell (Chair Person)	University of Virginia
Francesco Paresce	European Southern Observatory
Abhijit Saha	National Optical Astronomy Observatory
Joseph Silk	University of California, Berkeley
John Trauger	Jet Propulsion Laboratory
Alistair Walker	NOAO CTIO
Brad Whitmore	Space Telescope Science Institute
Rogier Windhorst	Arizona State University
Erick Young	University of Arizona

WFC3 Replaces WFPC2 in Radial Instrument Bay

Not Shown - WFC3 will reuse the EVA Radiator Handhold, Stowage Fixture and POM cover.



Detector Heat Pipes
Radiator Truss Assembly
LVPS
MEB #2
Electronics Radiator
DEB (under MEB)
Main (Detector) Radiator w/ Light Baffle
Blind Mate Connector
Optical Bench
MEB #1
CEB
Mechanism Cover
C-Latch
Pick-Off Mirror
Enclosure
A-Latch

WF/PC I H/W reuse
HST Heritage
New H/W

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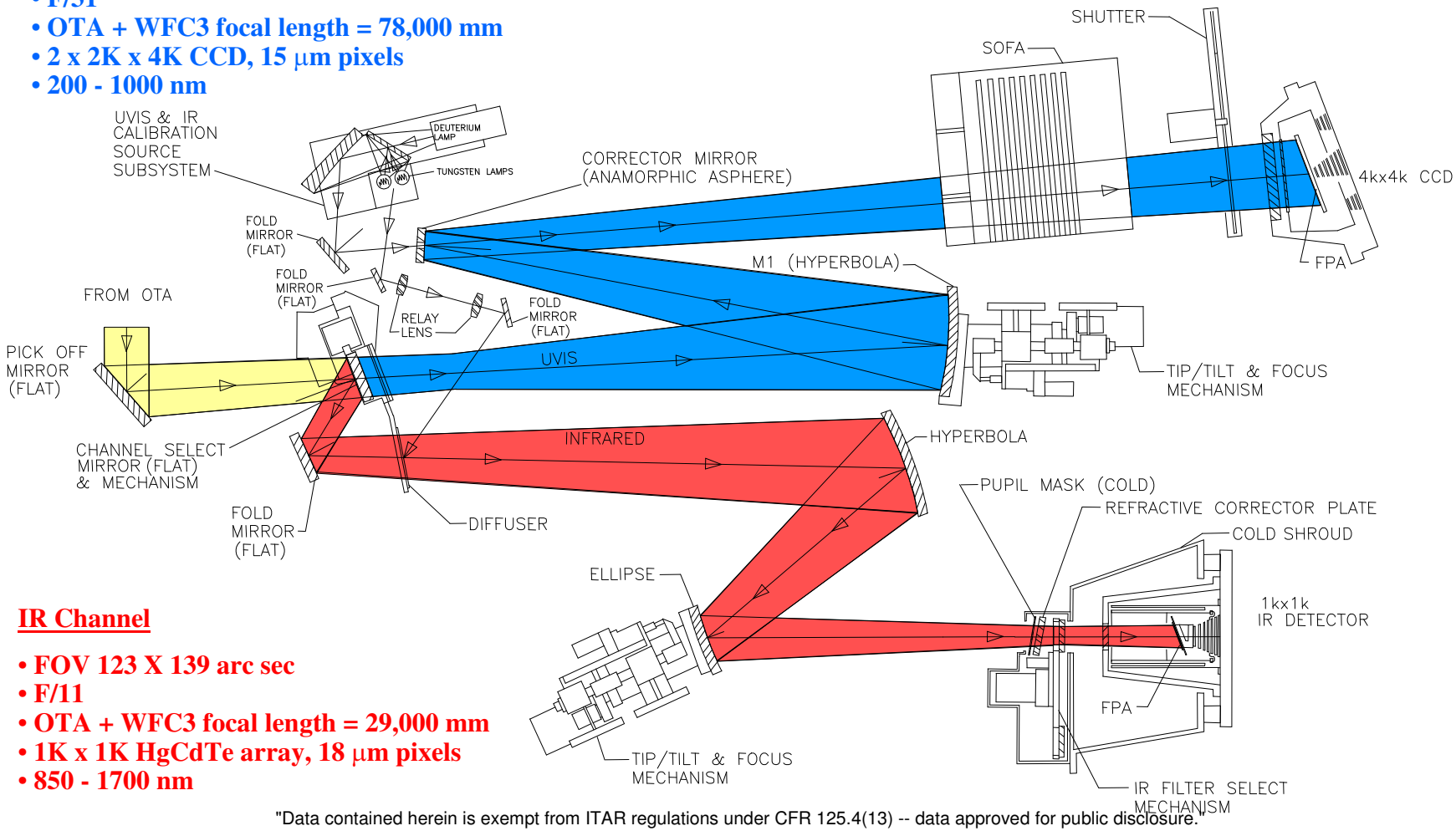
WFC3 Has Two Optimized Optical Channels

UVIS Channel

- **FOV 160 X 160 arc sec**
- **F/31**
- **OTA + WFC3 focal length = 78,000 mm**
- **2 x 2K x 4K CCD, 15 μm pixels**
- **200 - 1000 nm**



IR Channel

- **FOV 123 X 139 arc sec**
- **F/11**
- **OTA + WFC3 focal length = 29,000 mm**
- **1K x 1K HgCdTe array, 18 μm pixels**
- **850 - 1700 nm**

"Data contained herein is exempt from ITAR regulations under CFR 125.4(13) -- data approved for public disclosure."

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WFC3 Key Performance Parameters

	UVIS	IR	
Format	2 x 2K x 4K	1K x 1K	pixels
Field Size	160 x 160	135 x 135	arcsec
Pixel Size	39	130	mas
Spectral Range	200 to 1000	850 to 1700	nm
Dark Current	< 0.003	< 0.4	e-/pix/sec
Readout Noise	< 4	< 15	e-/pix/ readout
Operating Temp	-90	-120	˚C

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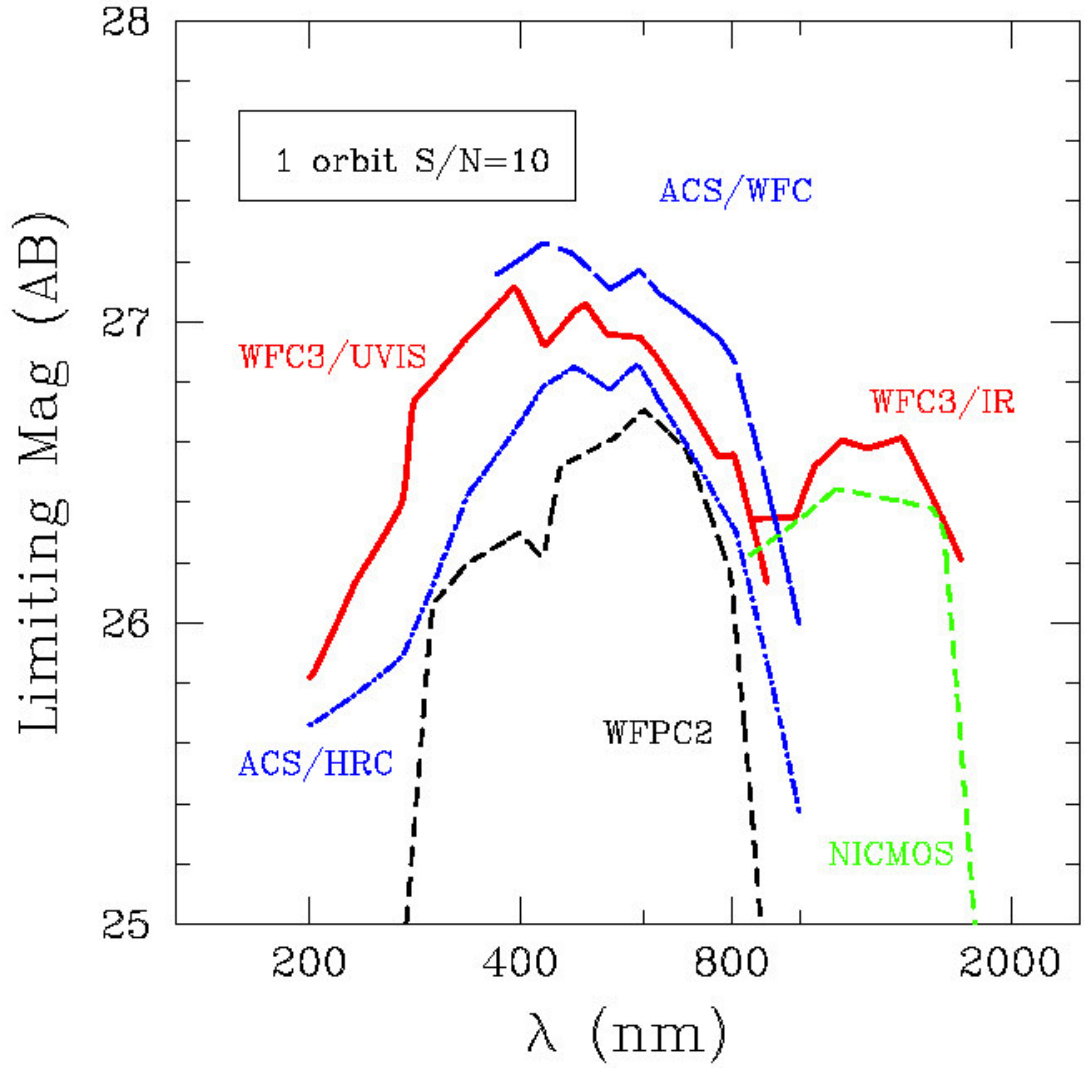
WFC3 Provides Unique NUV/NIR Sensitivity for HST



Sensitivity vs. wavelength with nominal R = 5 filters

WFC3/IR curve calculated for QE, read noise of FPA #58, currently in hand – greater advantage expected for final flight detector.

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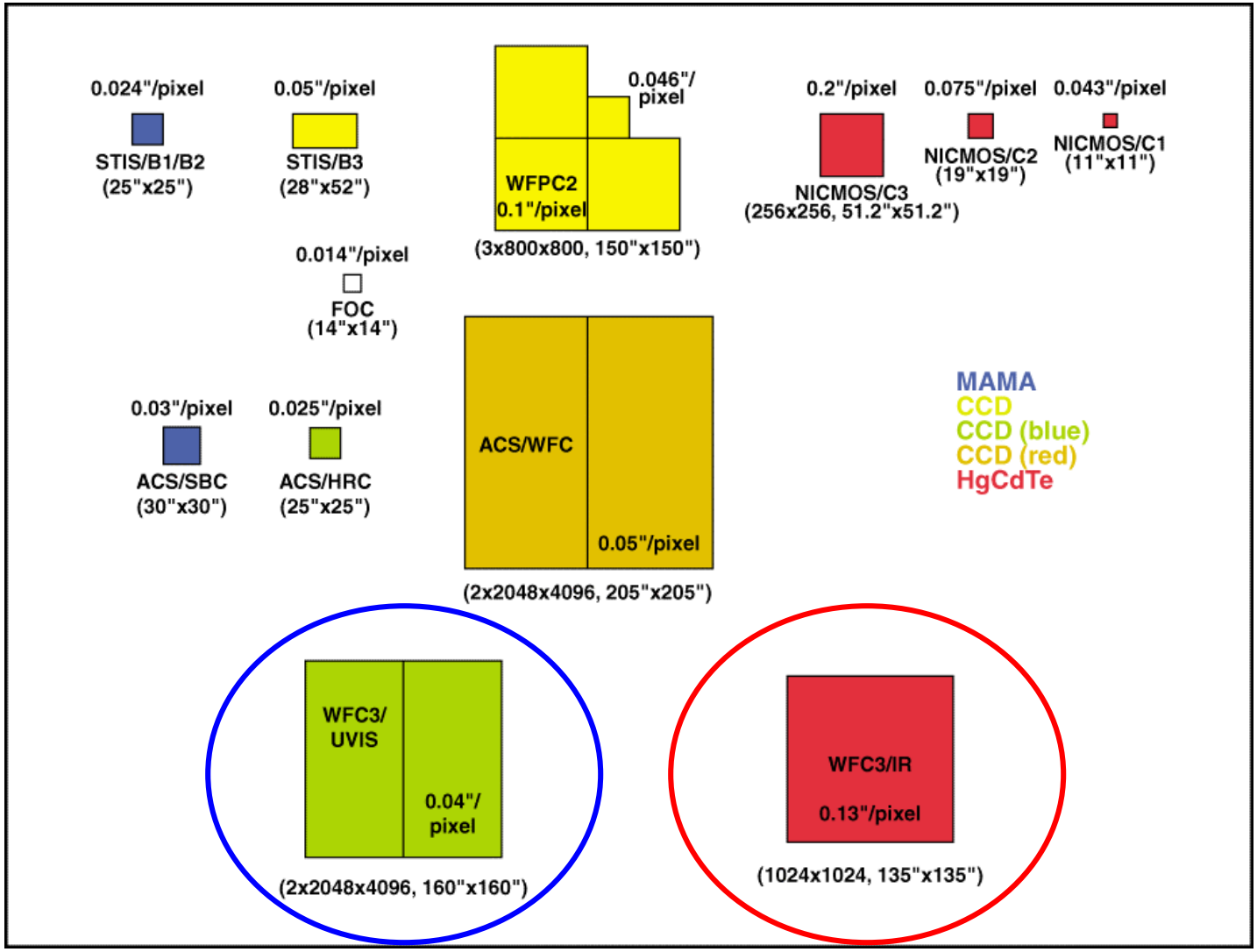
WFC3 Advances HST Imaging FOV



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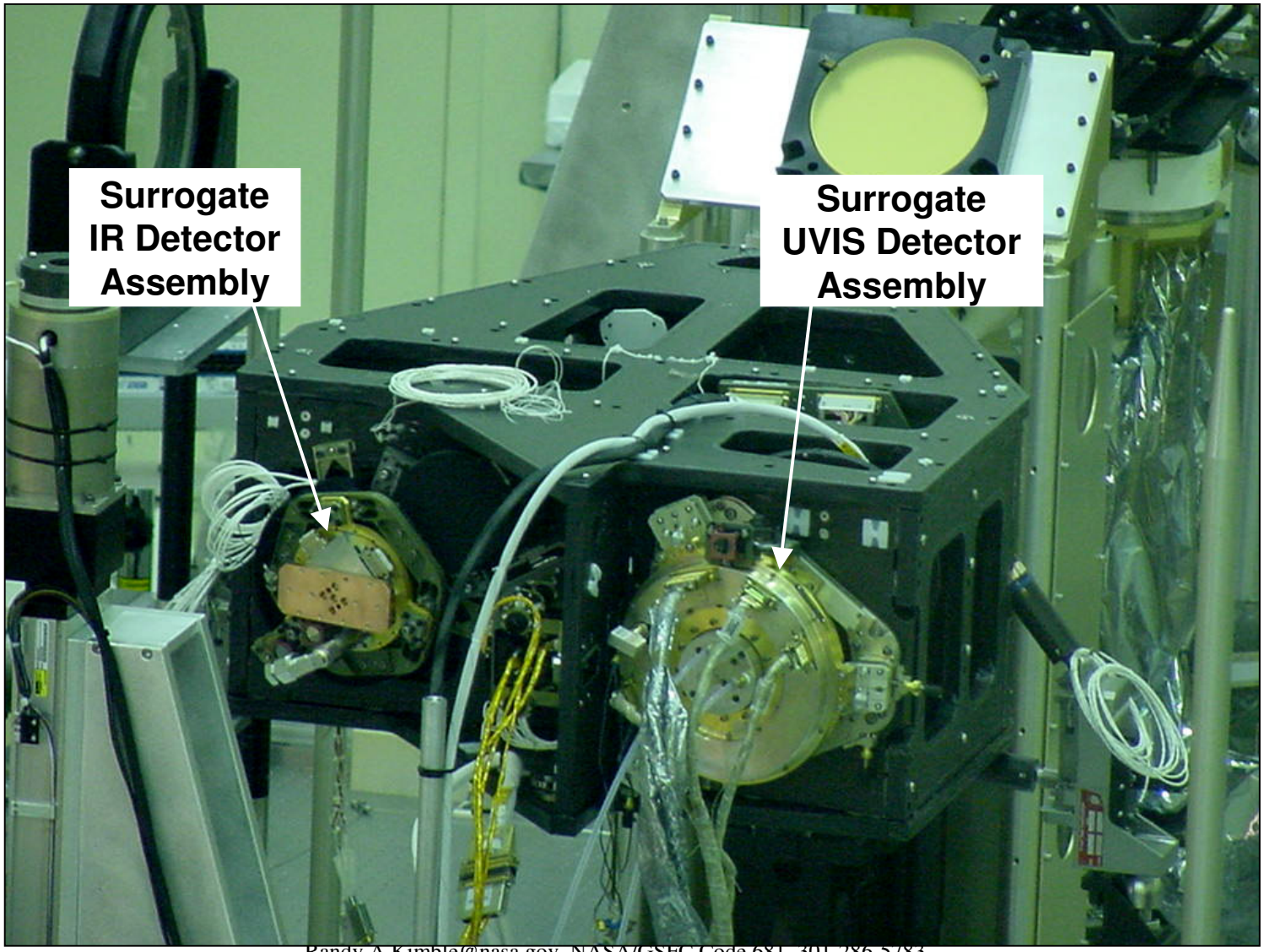
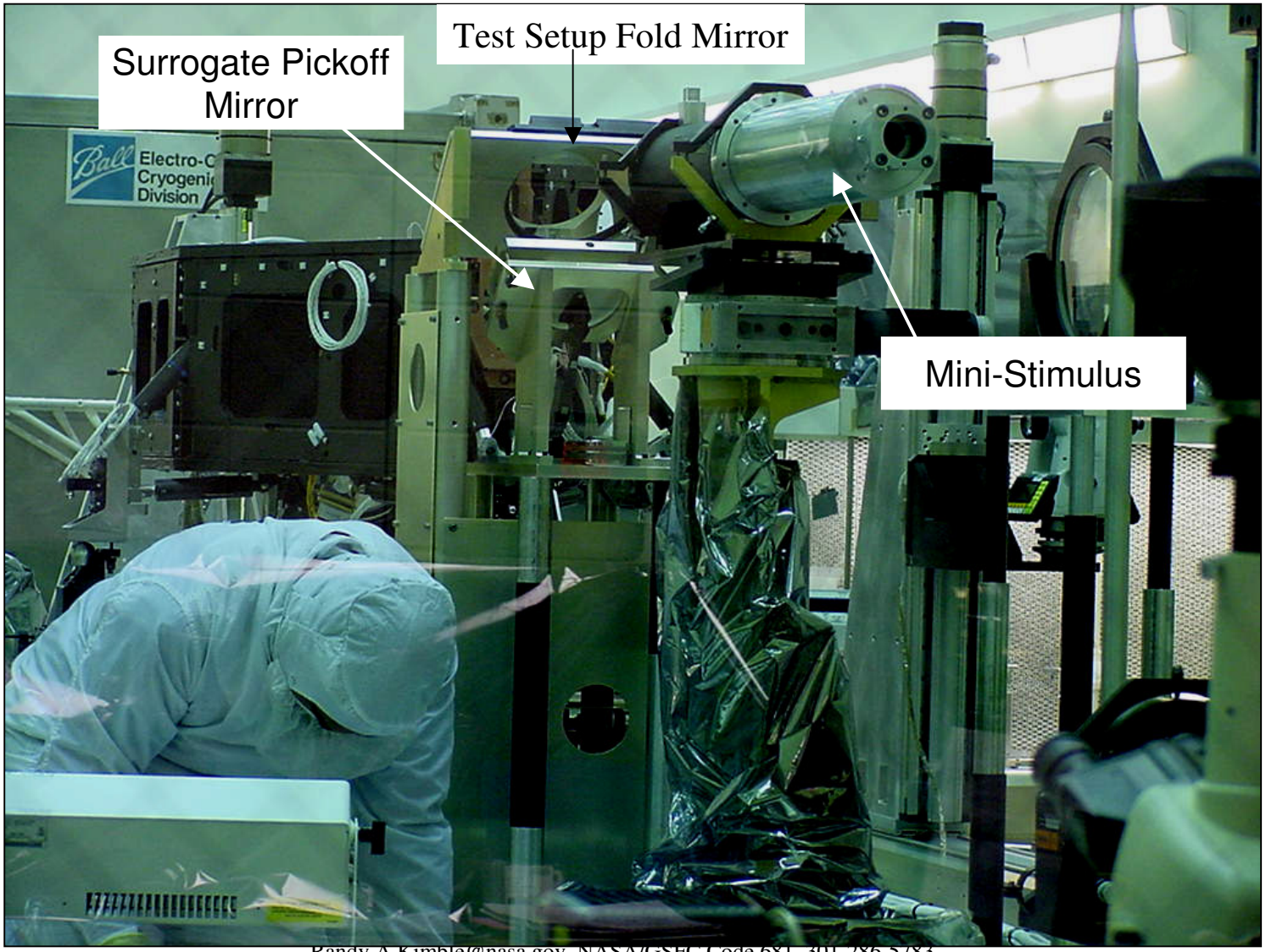
Optical Bench is Fully Populated and Aligned



"Mini-Stimulus" Source Simulates Hubble's Spherical Aberration



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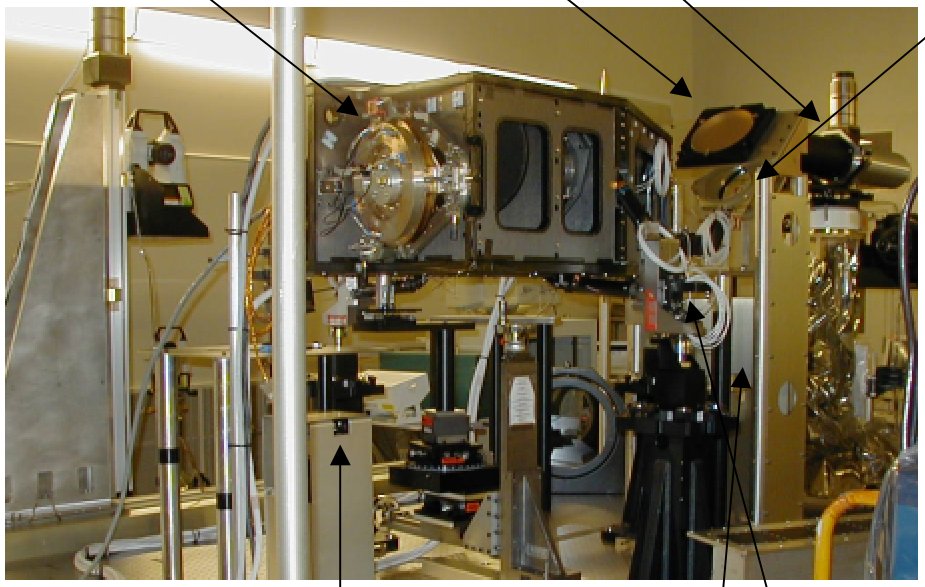
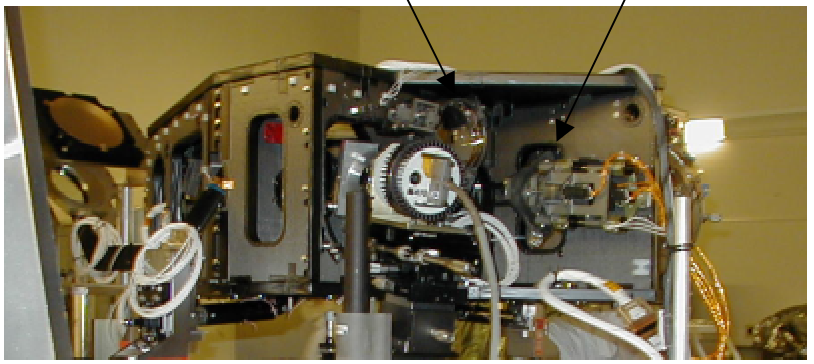
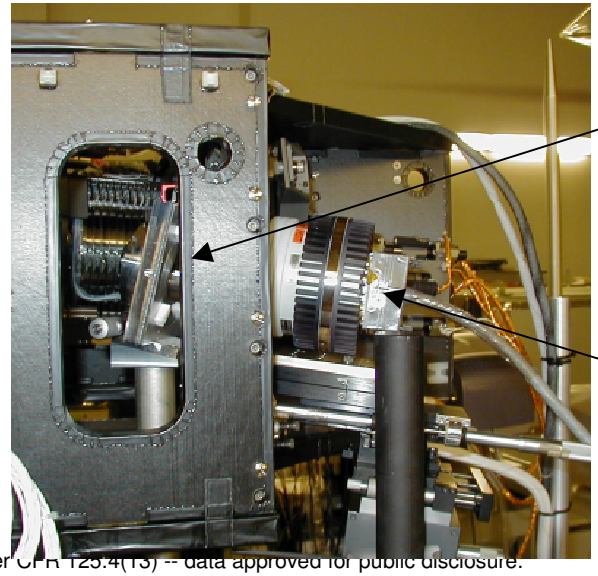
Mini-stim, WFAS & WFC3







Optical set-up and metrology are complex and precision activities with many data/reference transfers

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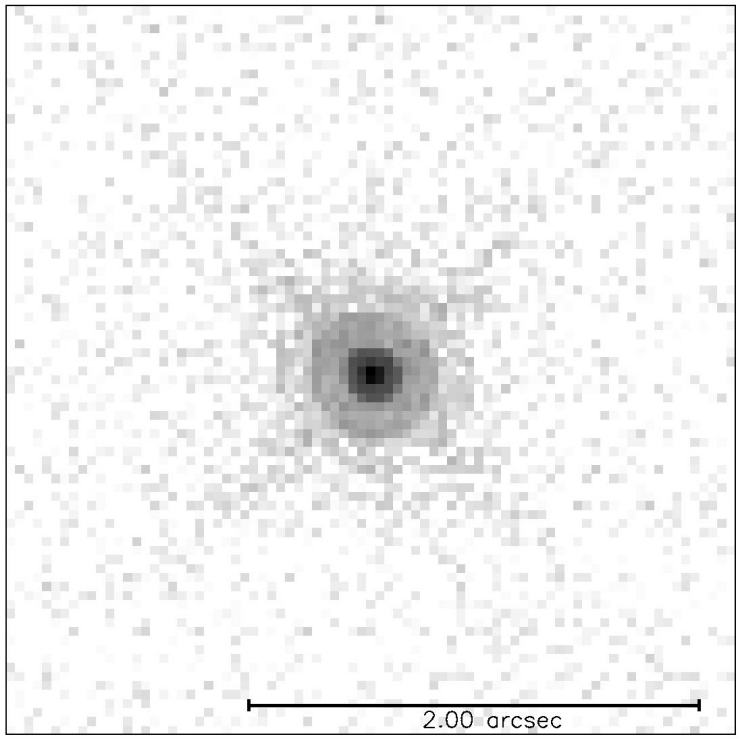
UVIS Encircled Energy Is Better Than Specification

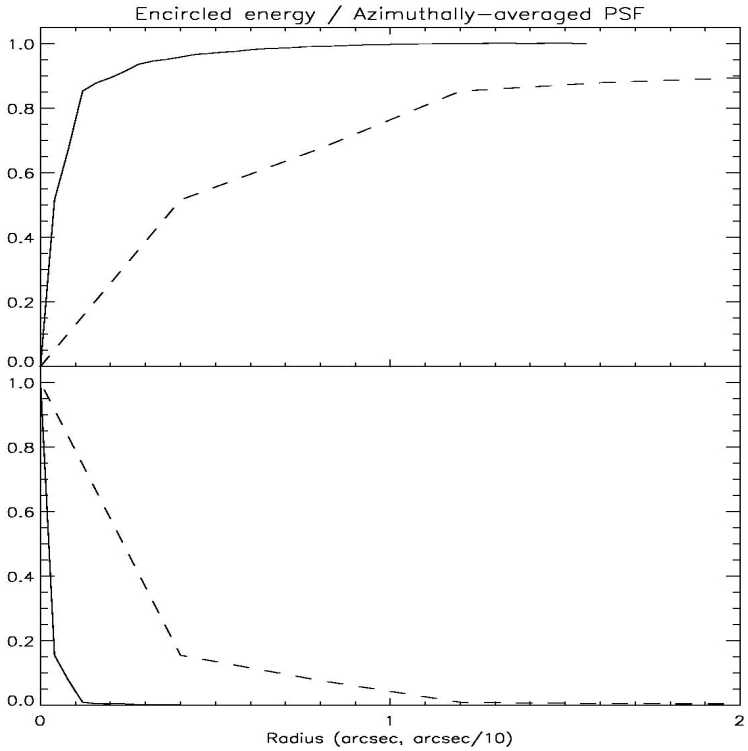
750 WFC3/UVIS AmpD

Field center; optimized

X center:	121.280	Background:	0.794318
Y center:	96.6300	Peak/total:	0.2057
Max value:	29642.2	Sharpness:	0.0833
Min value:	−26.8513	EE(d=.25):	0.8475
Total flux:	144368.57	EE(d=.40):	0.8948

} ⟷ { Spec EE at 633 nm (d=.25) = 75%





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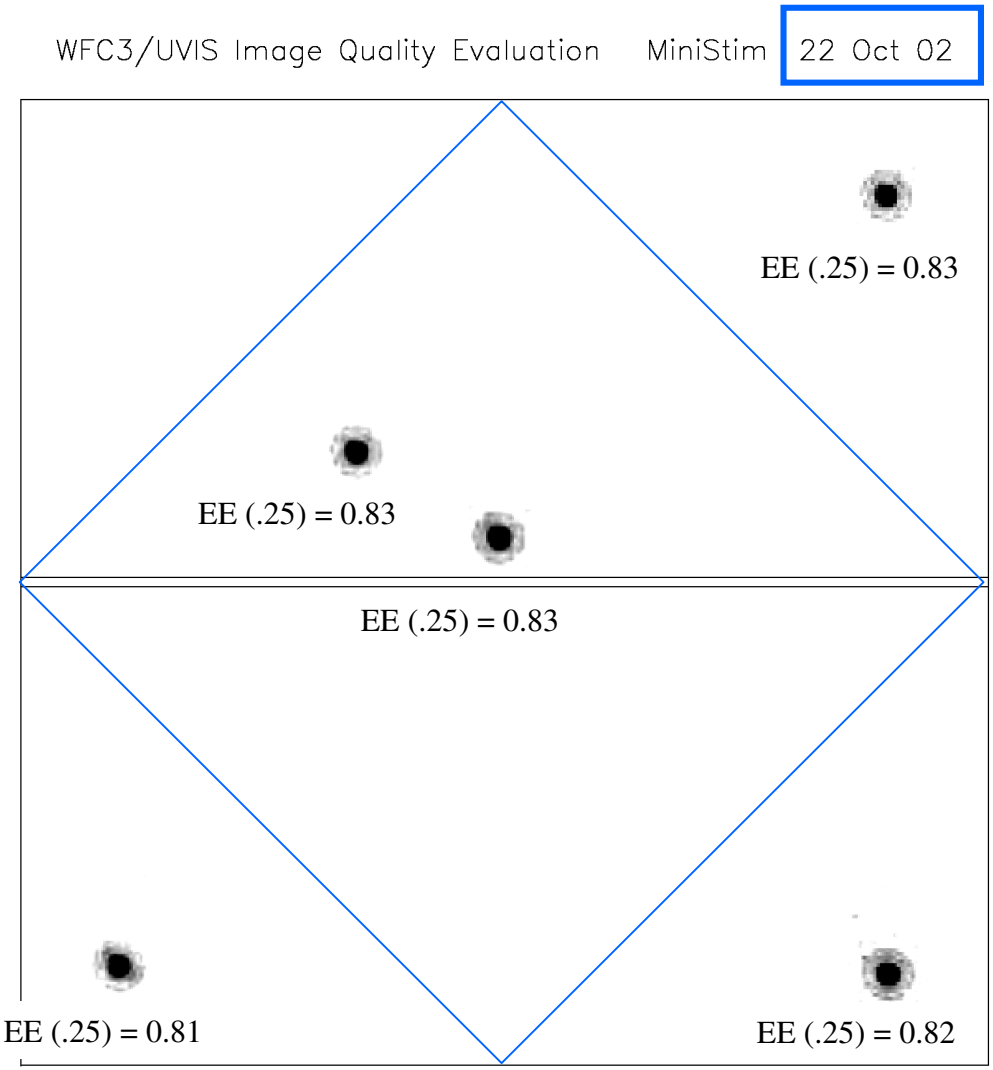
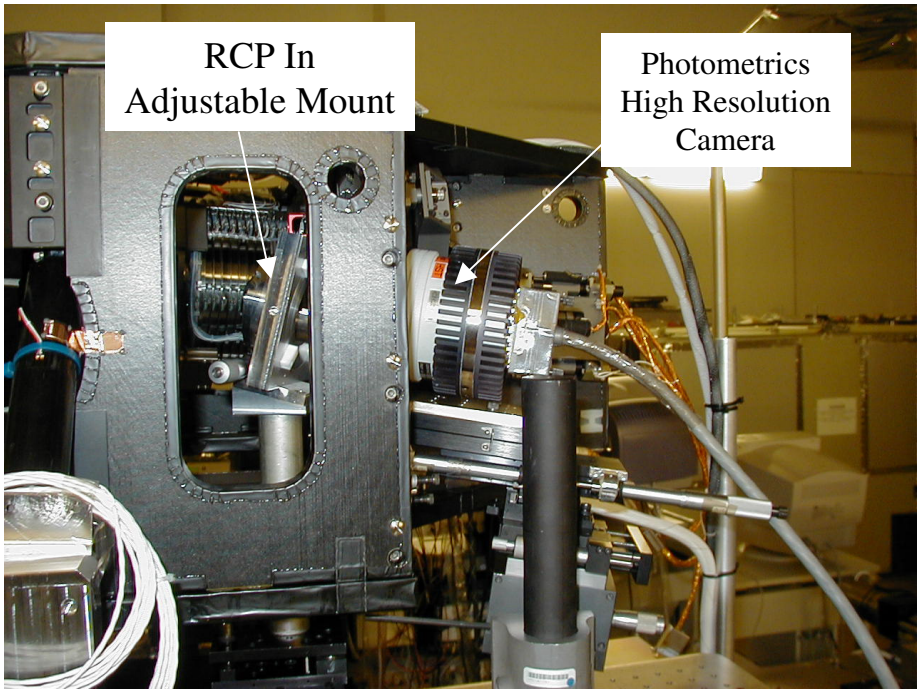
UVIS EE Good Over Field



Spec EE at 633 nm

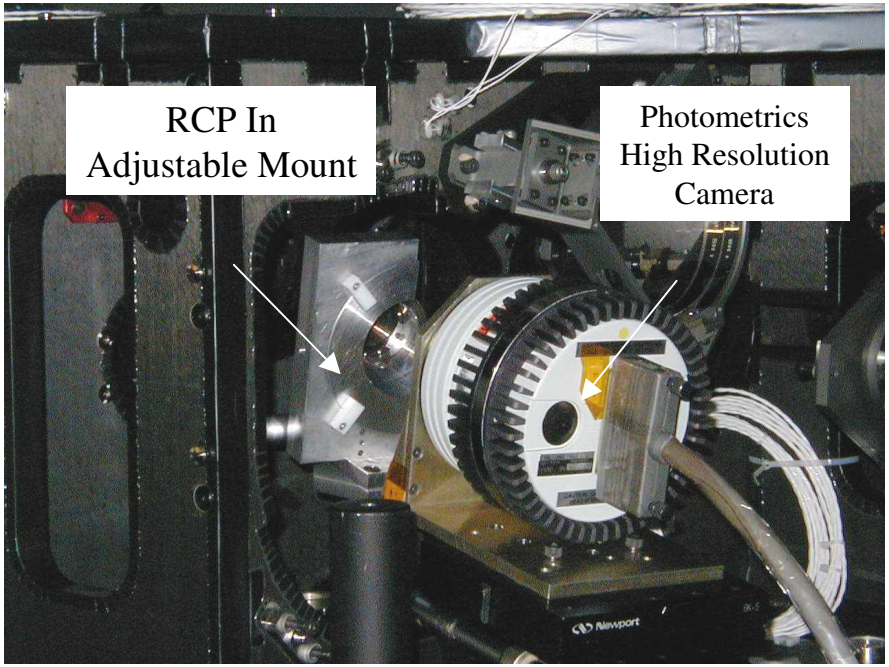
(d=0.25) = 75%

IR Refractive Corrector Alignment was Difficult but Ultimately Successful



Side view showing RCP installed in 6 degree of freedom adjustable mount with Photometrics high resolution camera installed in place of IR surrogate detector

View from back of optical bench



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IR Channel Encircled Energy at 633 nm Measured with Small-Pixel CCD

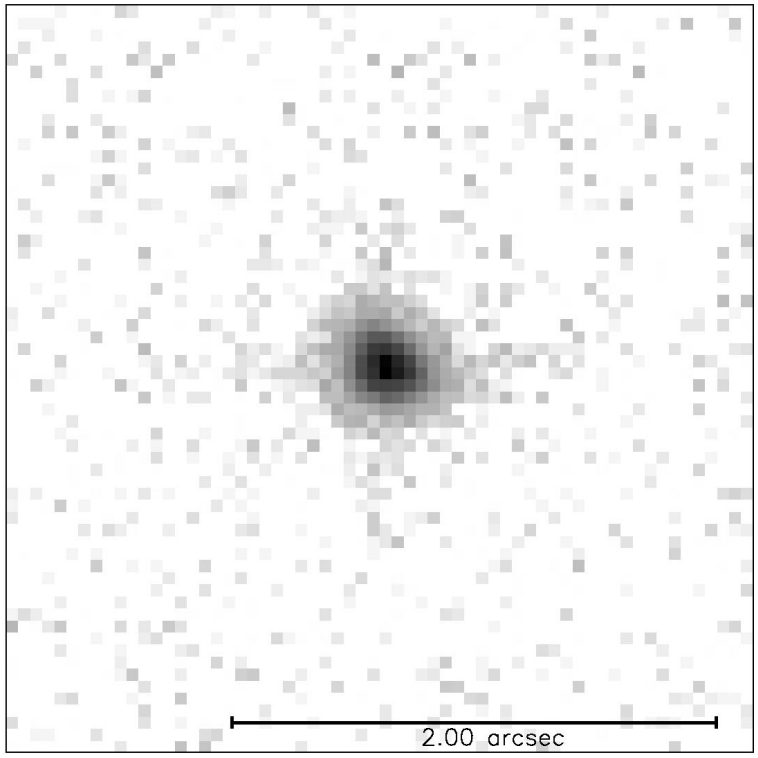
1012_17.fits WFC3/IRPM

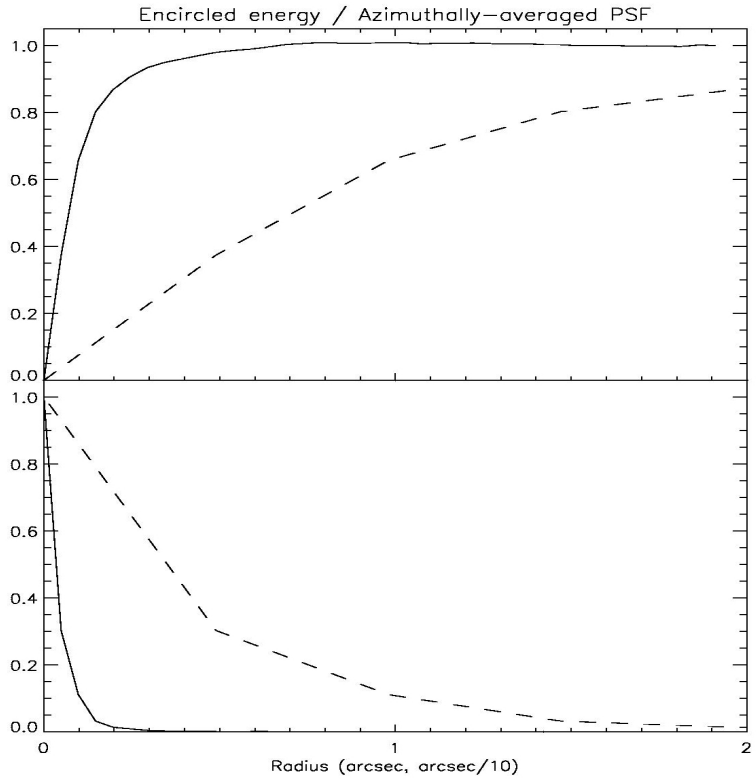
Field center; optimized

X center:	668.087	Background:	50.4349
Y center:	415.497	Peak/total:	0.1390
Max value:	3460	Sharpness:	0.0518
Min value:	23	EE(d=.25):	0.7367
Total flux:	24599.911	EE(d=.40):	0.8713

Above-spec performance achieved

EE Objective at 633 nm
(d=.25) = 67%
(d=.40) = 78%





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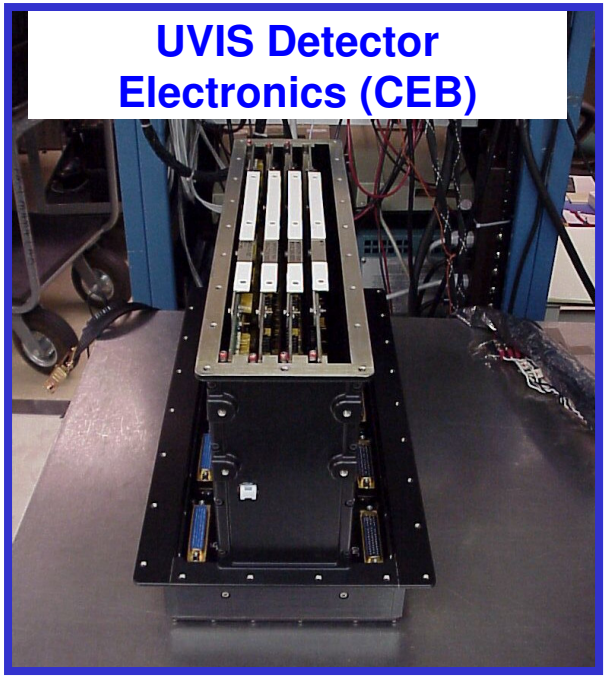
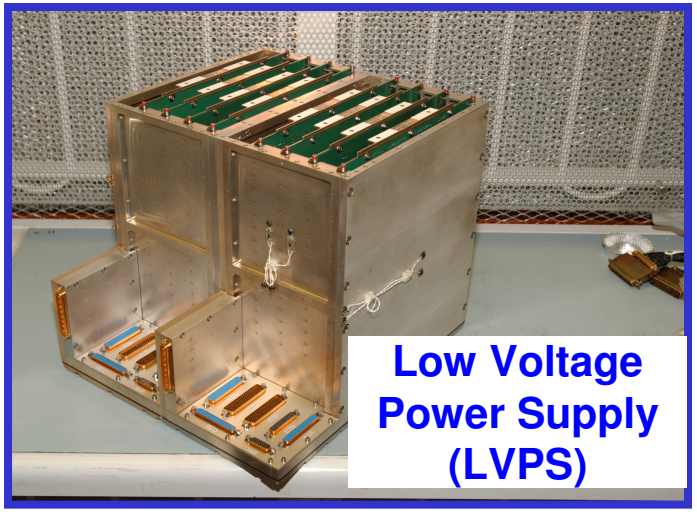
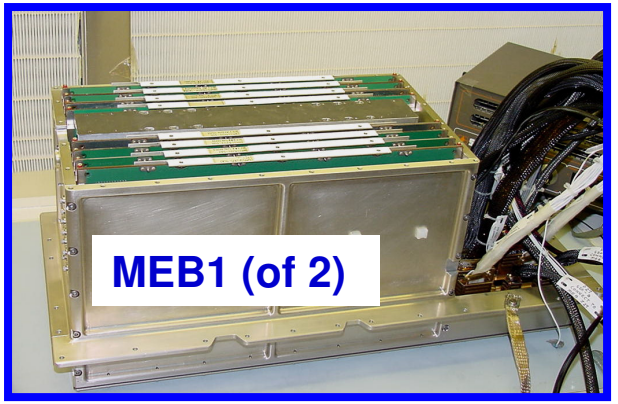
Principal Electronics Boxes are Complete - Several Delivered to GSFC

Detector e-boxes deliver <spec read noise.





LVPS, MEBs are at GSFC for environmental testing & integration.



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TECFIRE Redesign is Complete and Fully Qualified

- Cooling system for IR channel – TECFIRE – (based on TECs, heat pipes, radiator) presented severe engineering challenge.
- Original design placed unacceptable mechanical loads on brittle TECs and sheared them.
- Major redesign developed incorporating gelvet (thermally conductive, mechanically compliant material).
- Through all qualification tests successfully with performance margin; tolerant to failure of single TECs.
- Gelvet successfully completed life cycle test; TECs well into similar test with no problems expected.

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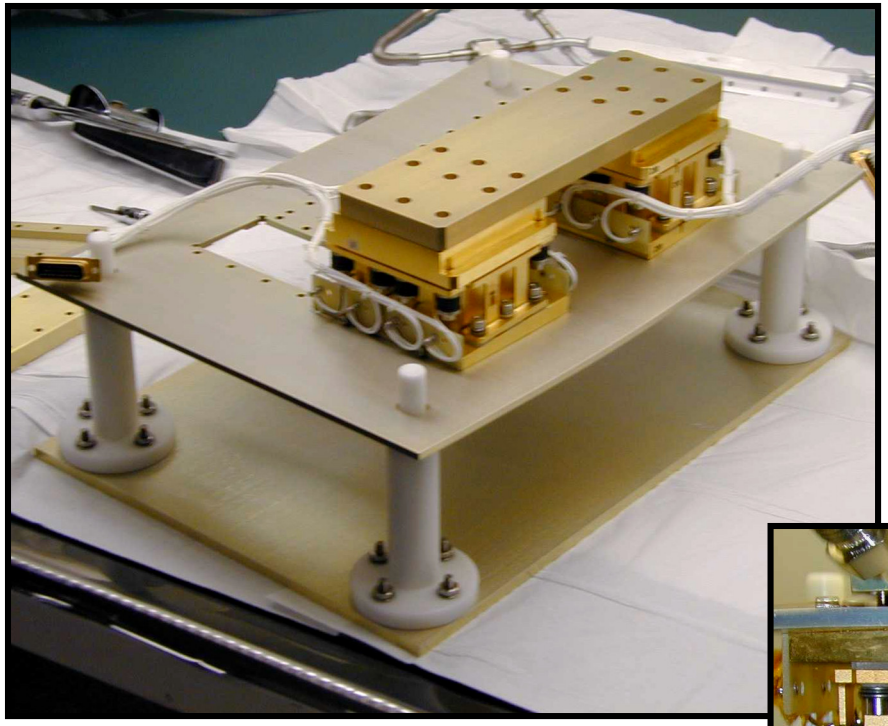
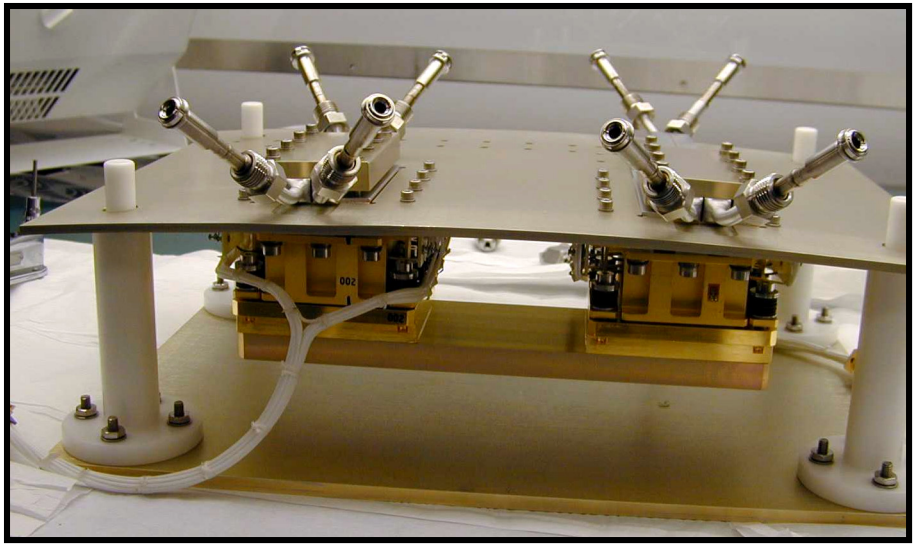
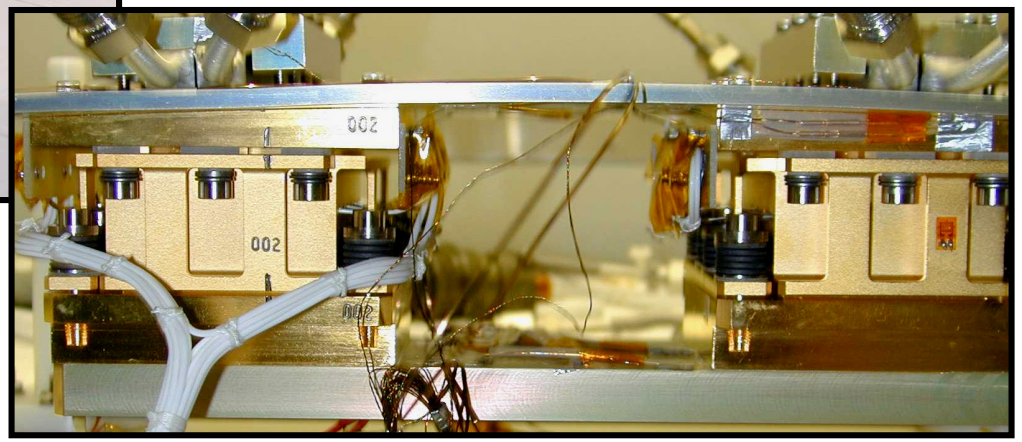
TECFIRE
'Detector Base' ETU







ETU DB TECFIRE Modules mounted on a simulated WFC3 Radiator with simulated IR Flex Heat Pipe Saddle.

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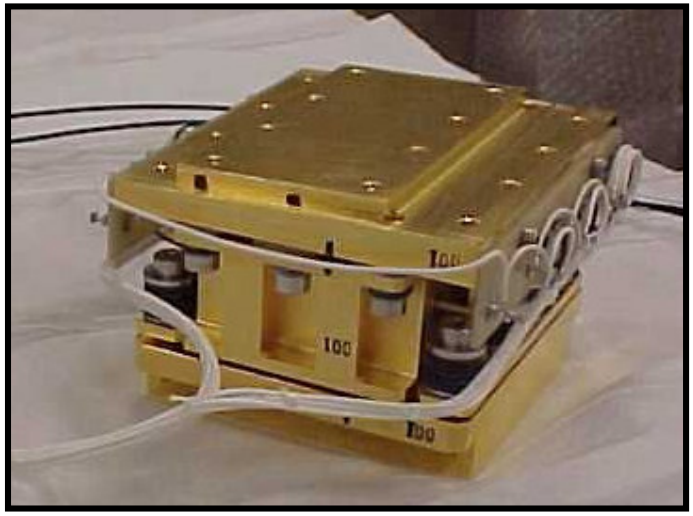
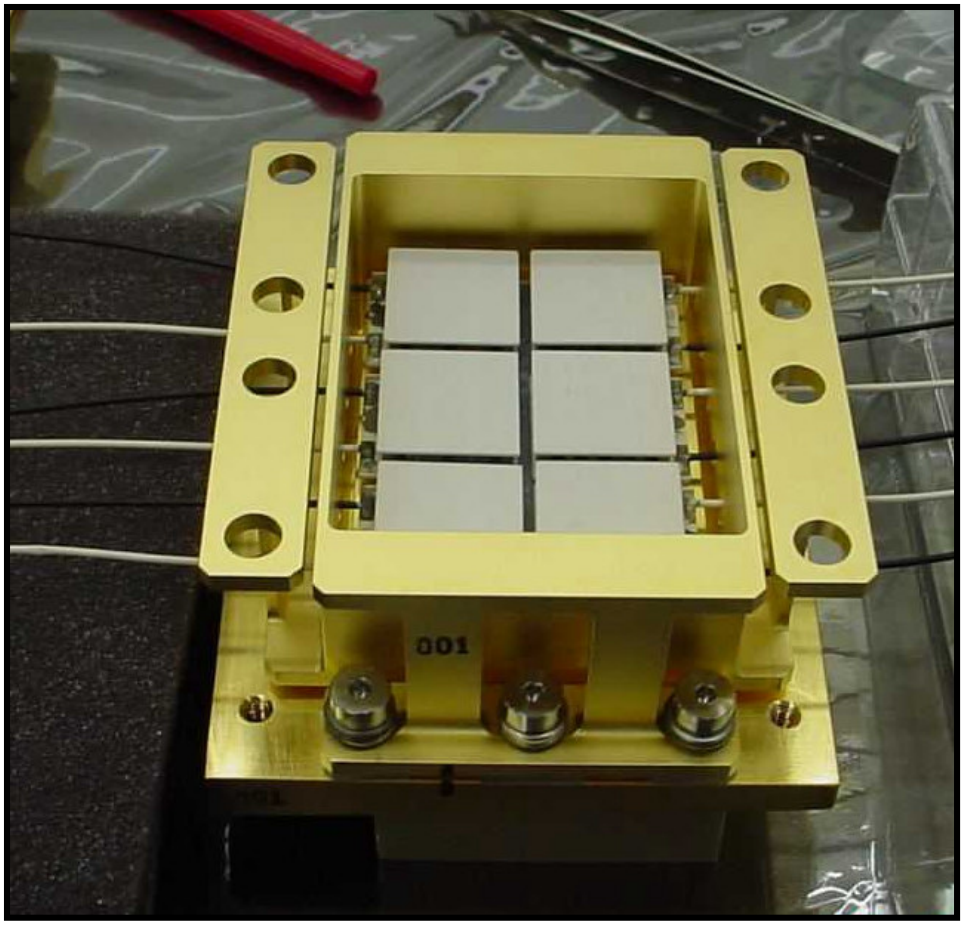
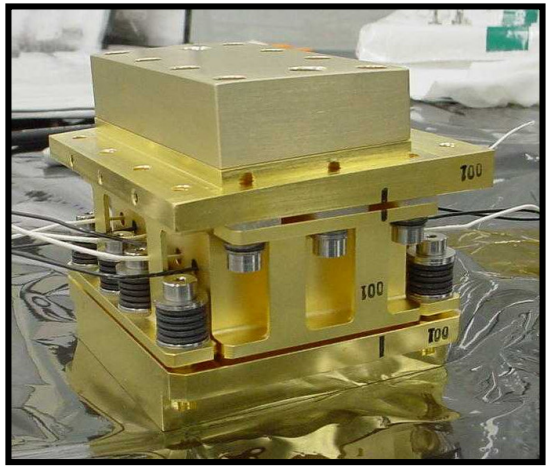
ETU TECFIRE
Single Unit Module







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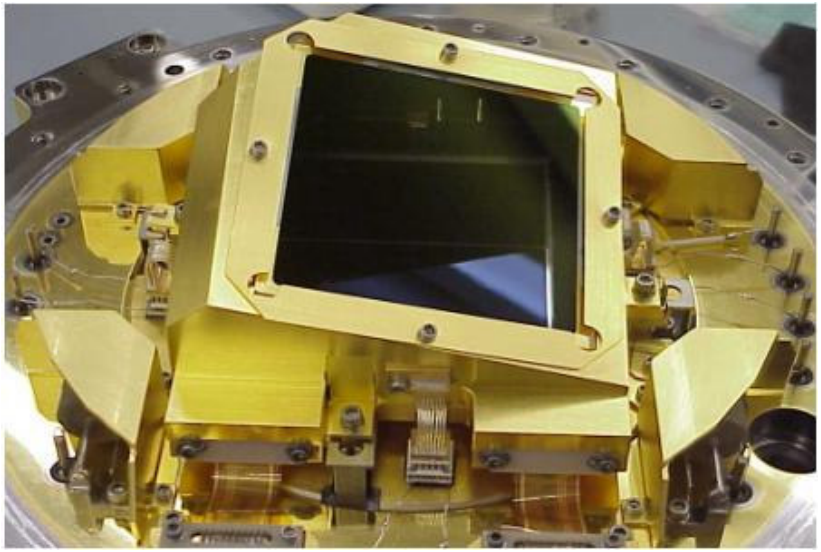
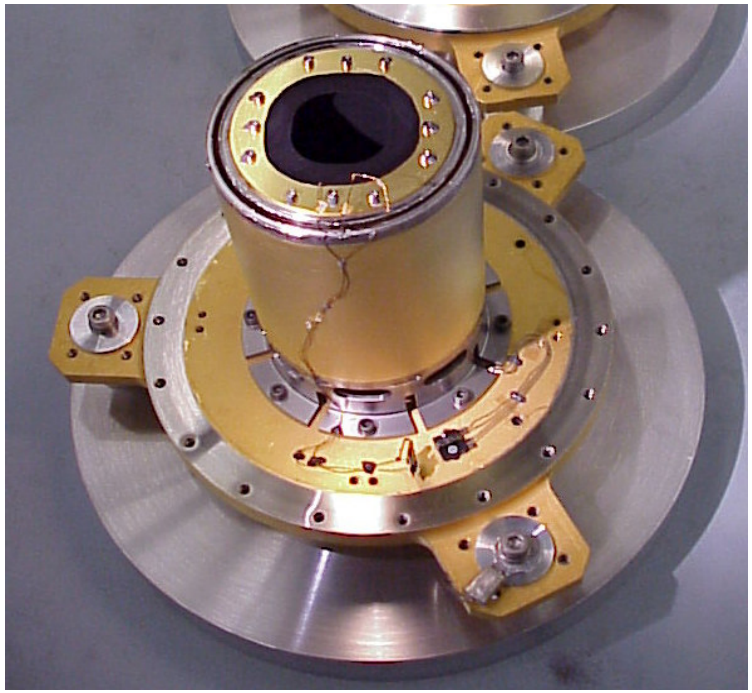
Detector Status



- UVIS detector Build 1 is fully assembled, into environmental test.
- UVIS Build 2 is in work.

IR Qual Unit (Vacuum Shell Removed)



- IR Qual Unit has completed thermal testing with performance margin.

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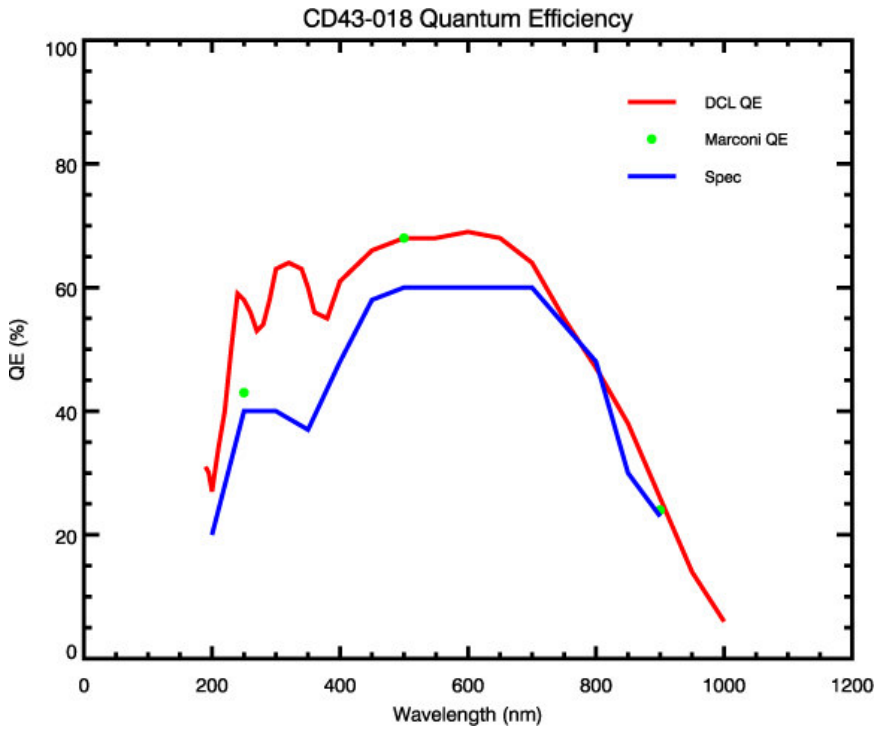
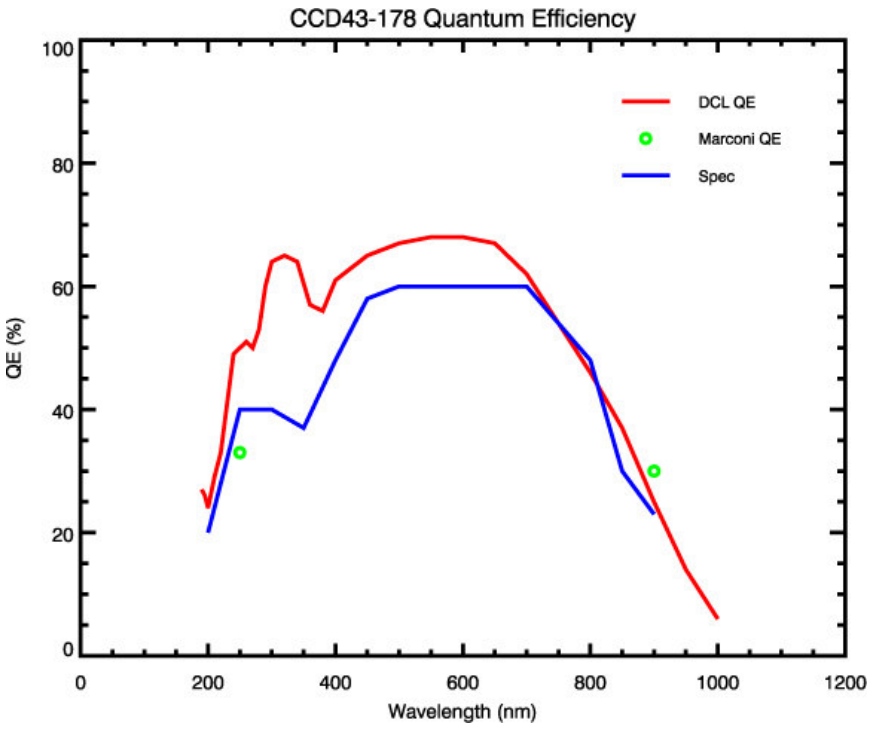
UVIS Build 1 Incorporates Superb Marconi CCDs

- Flight CCDs have above-spec QEs, <3 e- rms read noise (3.5 e- with flight electronics), as well as excellent CTE, dark current, and cosmetics.





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Charge Injection Selected as CTE Mitigation Strategy

- DCL has completed tests comparing charge injection and pre-flash performance for ameliorating CTE loss.
- DCL and STScI analyses concluded that charge injection offers superior performance.
- SOC concurred with recommendation to adopt charge injection for flight implementation (pre-flash hardware is still available).

	Pre-Rad	5 Years Radiation Damage		
		Uncorrected	Charge Injection	2000e^- Flat Field
CTE	0.999999	0.99984	0.999988	0.999978
^{55}Fe Charge Loss (2048 Transfers)	0.20%	28%	2.40%	4.40%
Noise Baseline	3e^-	3e^-	15e^-	46e^-
^{55}Fe Noise	15e^-	20-100e^-	20e^-	53e^-

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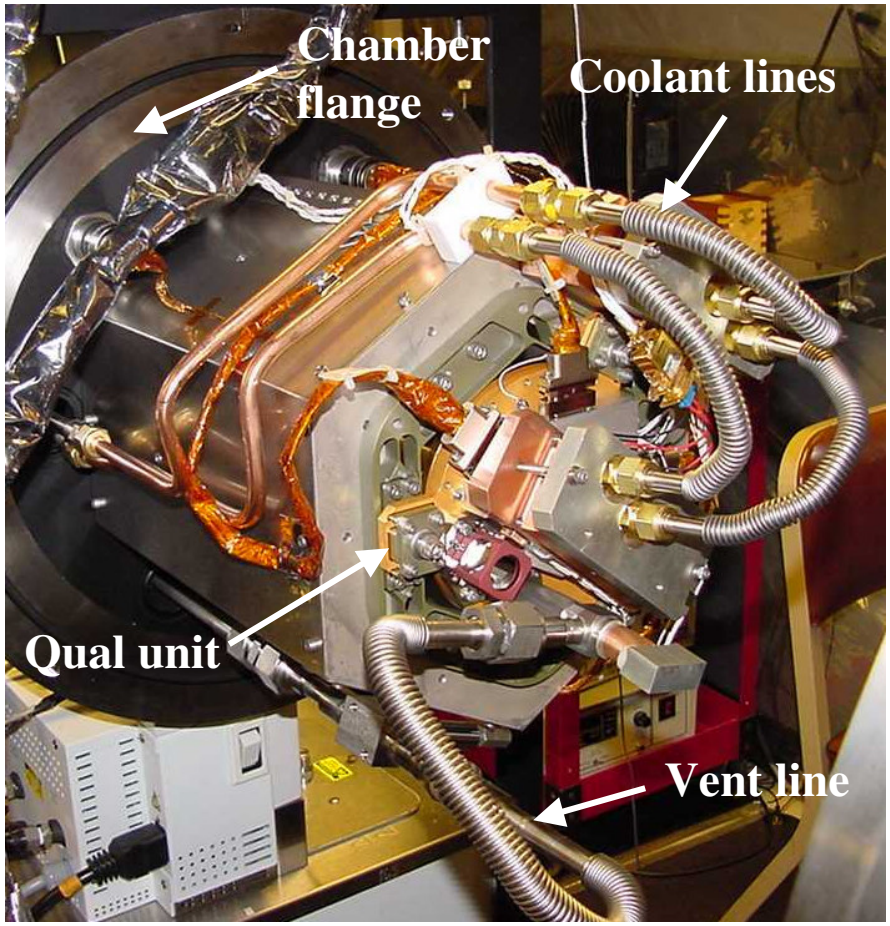
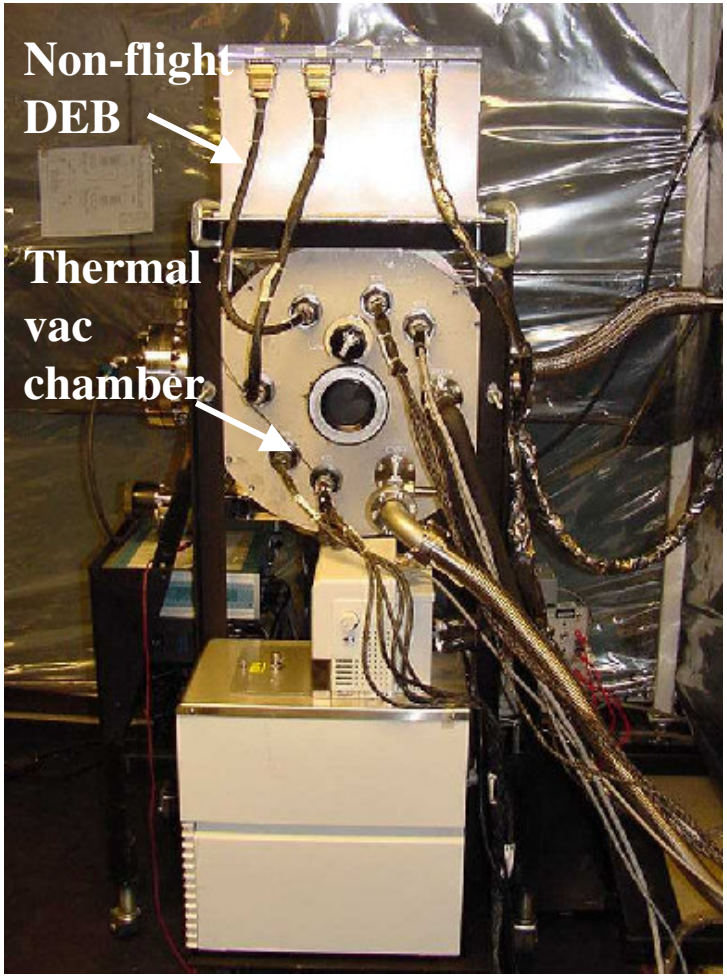
IR Qual Unit Successfully Completed Thermal Vacuum Testing w/Margin



Qual unit installed on thermally-isolating structure inside thermal vac chamber



FA-2 vacuum chamber and DEB

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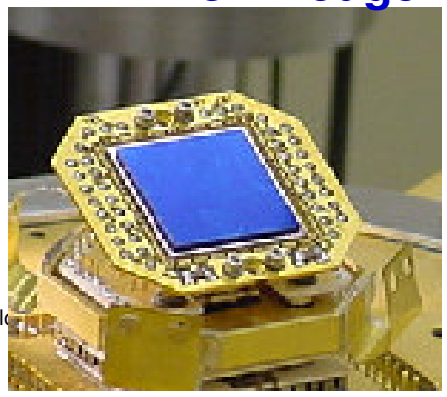
IR Focal Plane Assembly Development Efforts are Paying Off

- Development of the short-wavelength-cutoff HgCdTe array for operation at 150K has been the biggest technical challenge of the program.
- Problems have been encountered in achieving good short wavelength QE, dark rate stability, and spec level read noise.
- Systematic development steps at Rockwell, with crucial performance feedback from DCL, have led to great progress.
- The current lot is yielding the best devices to date.
- ***A flyable part, that would offer exciting performance in WFC3, is currently in hand.***
- An additional lot is still in fabrication with the potential for further improvements.

IR FPA on wedge



"Data contained herein is exempt from ITAR regulations under CFR 125.4(13) -- data approved for public disclo

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IR FPA Problems Have Been Systematically Investigated

- Lot 4 parts showed severe QE shortfall at short wavelengths; below spec and below NICMOS; corrected superbly in lot 6.
- Lot 6 parts, however, showed severely unstable dark current after resets or exposure to light (some devices showed settling times of 10's of hours) – precludes straightforward on-orbit operations/calibration, though some encouraging progress has been made in developing operational strategies.
- All devices have had higher than spec readout noise (30-45 e- rms per CDS pair was typical in early lots).

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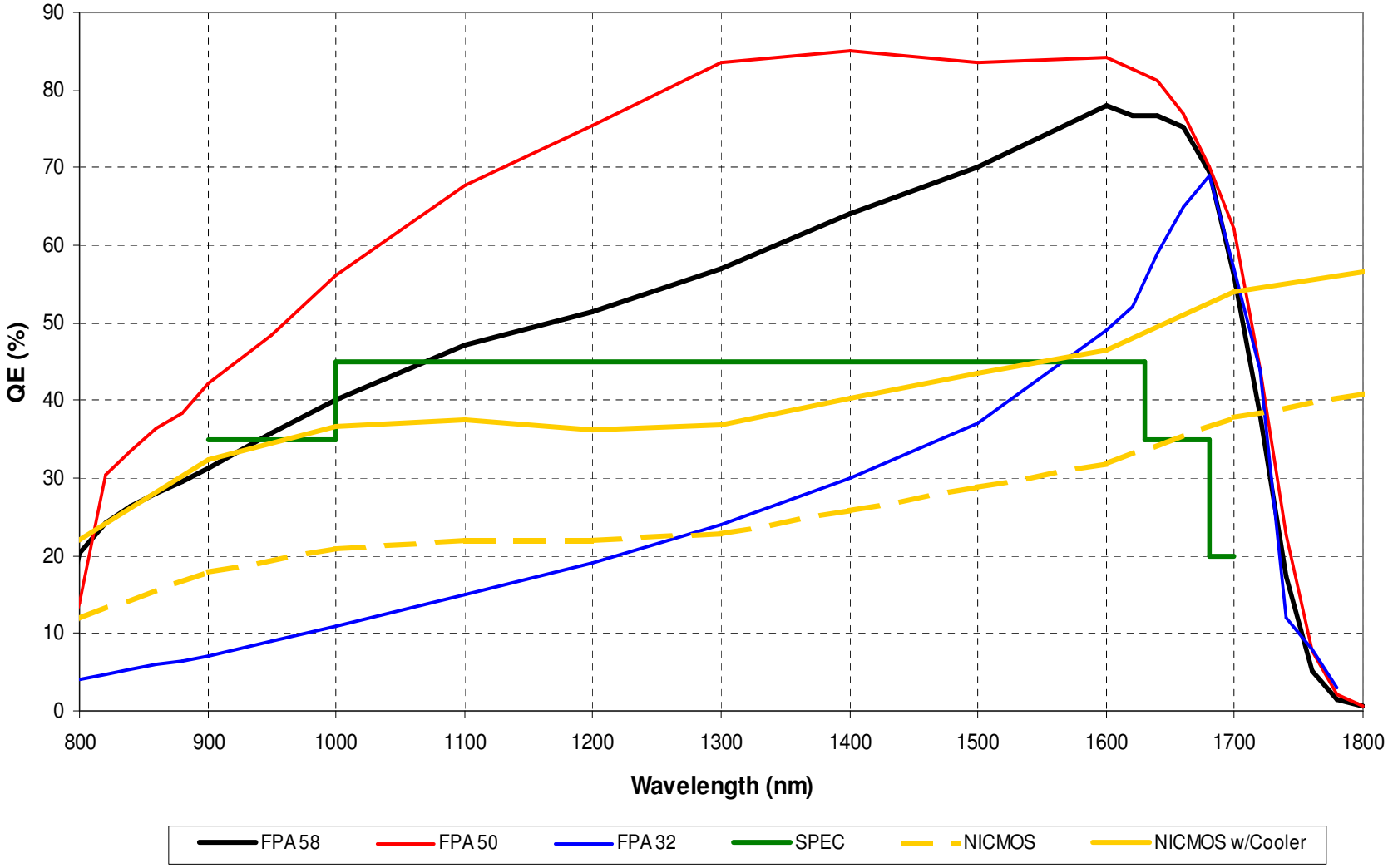
IR Detector QE Comparison
Including Best Current Candidate FPA 58



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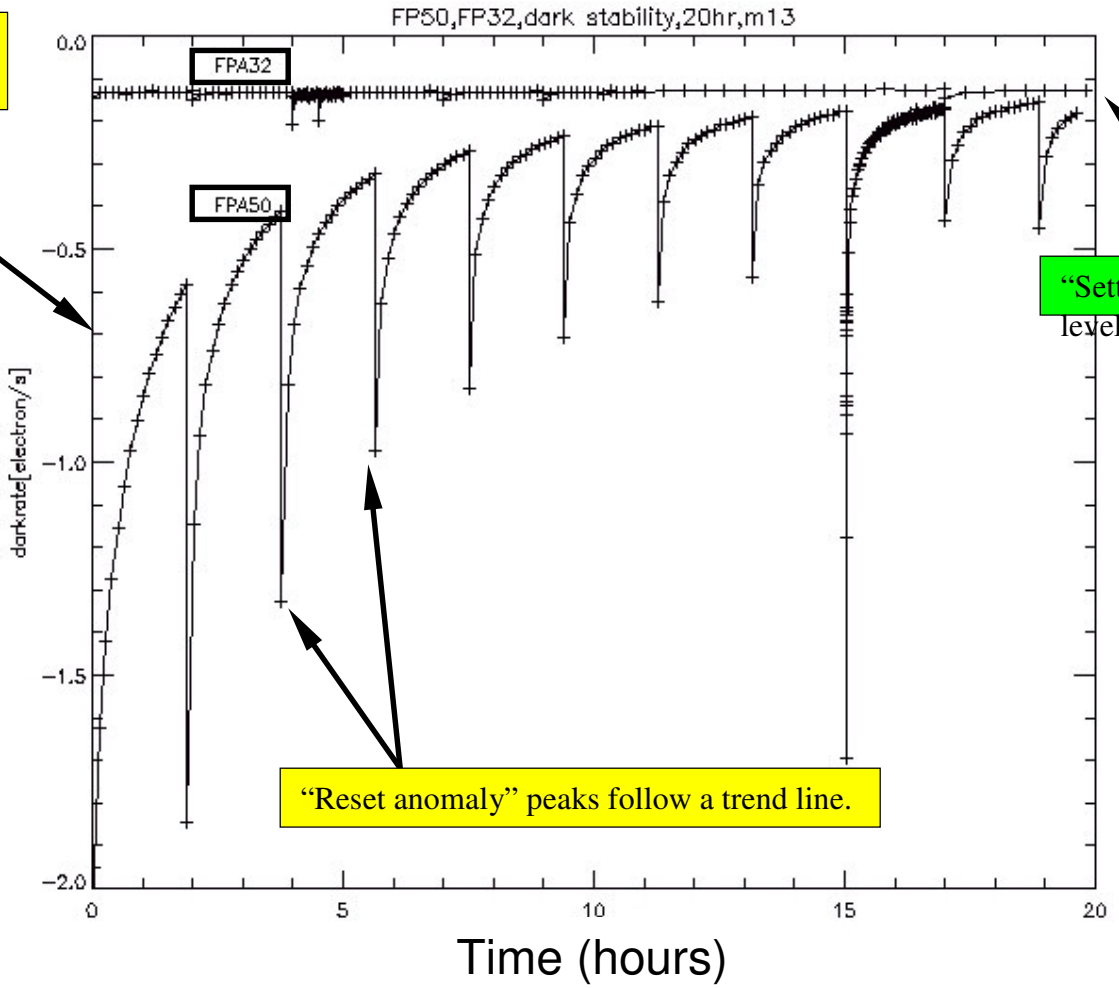
FPA 32/50 Stability Comparison

Data taken immediately after 3/4 full-well flat field.



"Settled" dark current level.

Equivalent dark current RATE (derivative of the raw ramp signal).

"Reset anomaly" peaks follow a trend line.

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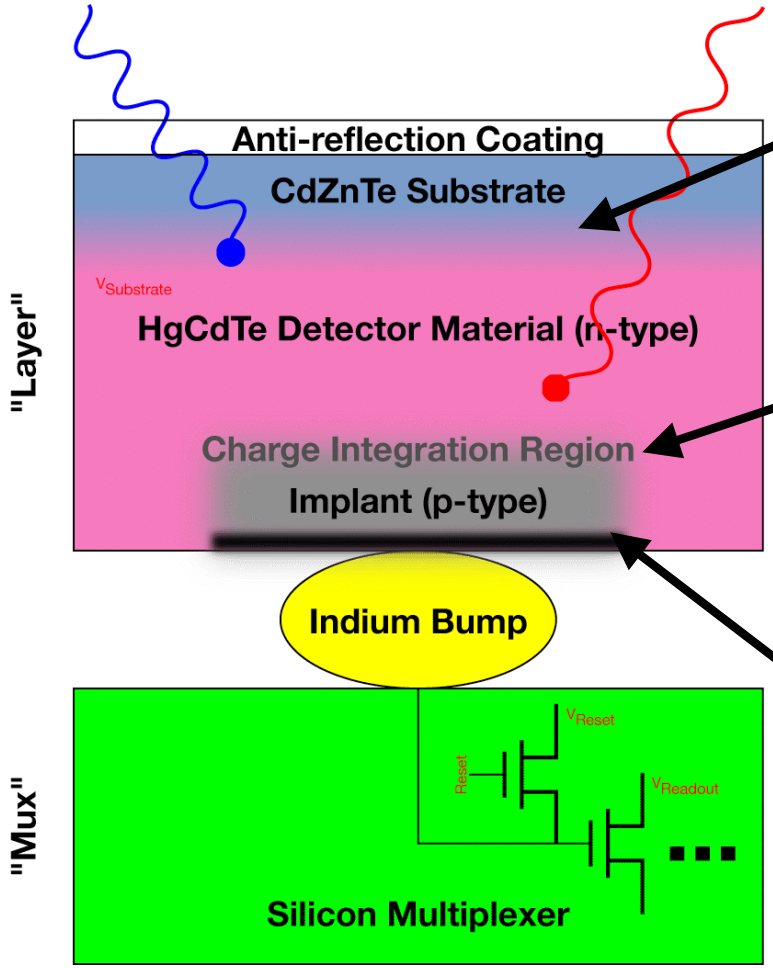
IR FPA Performance Issues are Physically Separable and Correctable in a Single Device



Short wavelength QE problem caused by traps in buffer region – cure with composition gradient to minimize lattice mismatches.

Instability associated with traps in charge integration region. Address with implant density/depth.

Readout noise shows temperature dependence characteristic of Johnson noise (resistive component) and 1/f drift typical of surface state trapping. Improve contact resistance and surface properties.

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Fabrication Status at Rockwell

- Lot 7 initiated to combine lot 4 stability approach with lot 6 QE, along with small parameter tweaks to improve read noise.
- 1st split (lot 7A) validated QE process and yielded best cosmetics and hybridization to date, but exhibited anomalously high dark current.
- Rockwell introduced IR&D lot at company expense to resolve dark current problem and optimize parameter mix for WFC3 lot 7B.
- IR&D wafers are currently in test at RSC and DCL – best devices to date for combination of QE, dark rate, stability, and noise.
- Lot 7B layers are grown; will be processed with best recipe determined from IR&D lot.

IR&D Lot Has Yielded Flight Candidate Device FPA 58

- FPA 58 is clearly the best IR FPA developed so far for WFC3.
  - QE is above spec everywhere longward of 1.05 microns.
  - Mean dark rate is 0.11 e-/sec vs. spec of 0.4 e-/sec.
  - Stability appears to be as good as best lot 4 parts.
  - Read noise is 23.5 e- rms per CDS pair and averages down further when read up the ramp.
  - 2 or 3 additional devices can be packaged from the same wafer.
- FPA 58 could be flown on WFC3 and offer exciting performance, though we of course would prefer to achieve full spec level performance with lot 7B.
- Devices from IR&D or lot 7B can be characterized by DCL and delivered to Ball for buildup of housing with no impact to I&T schedule.

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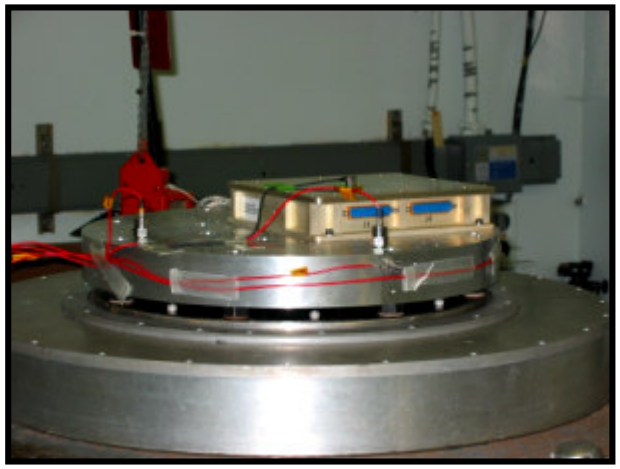
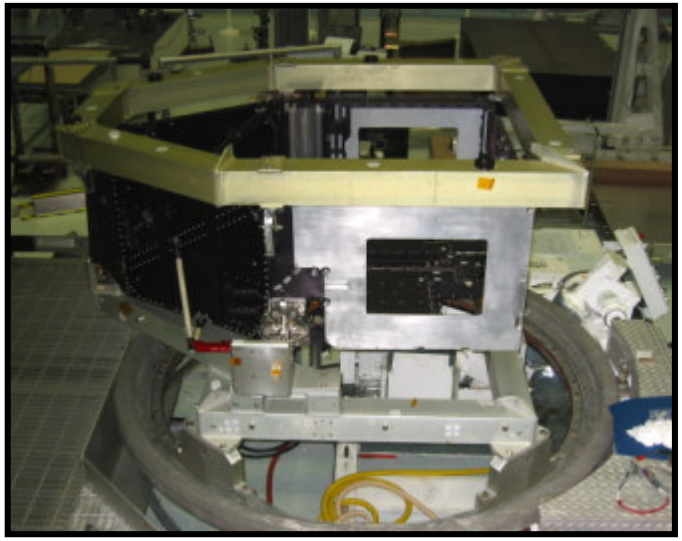
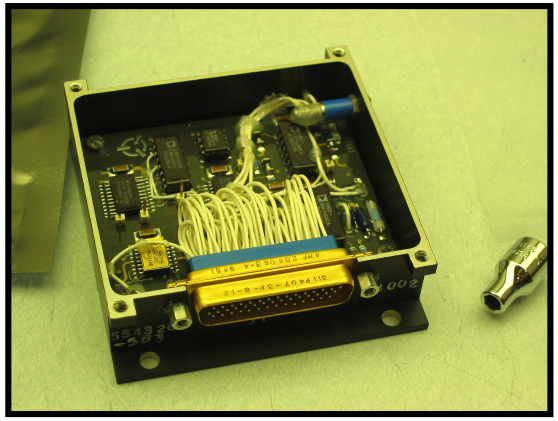
GSFC Is Ready for WFC3 I&T



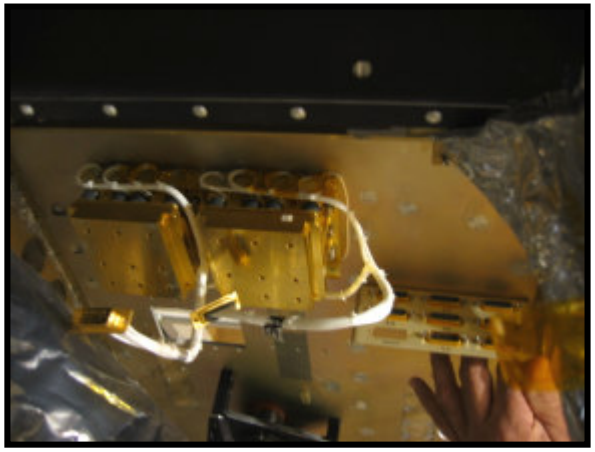
Filter Box Vibe



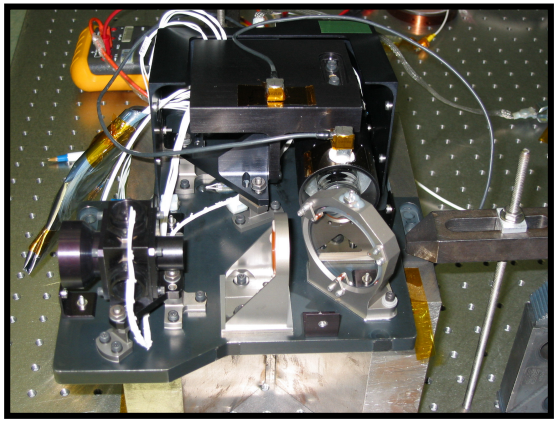
Enclosure ready for I&T



Heater Controller



TECFIRE Fit-Check



Calibration Source Alignment

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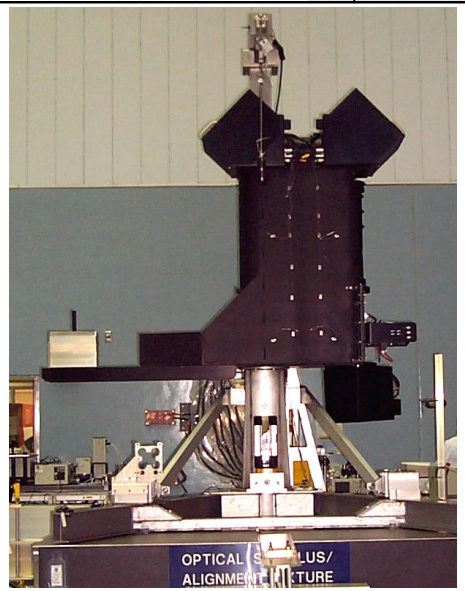
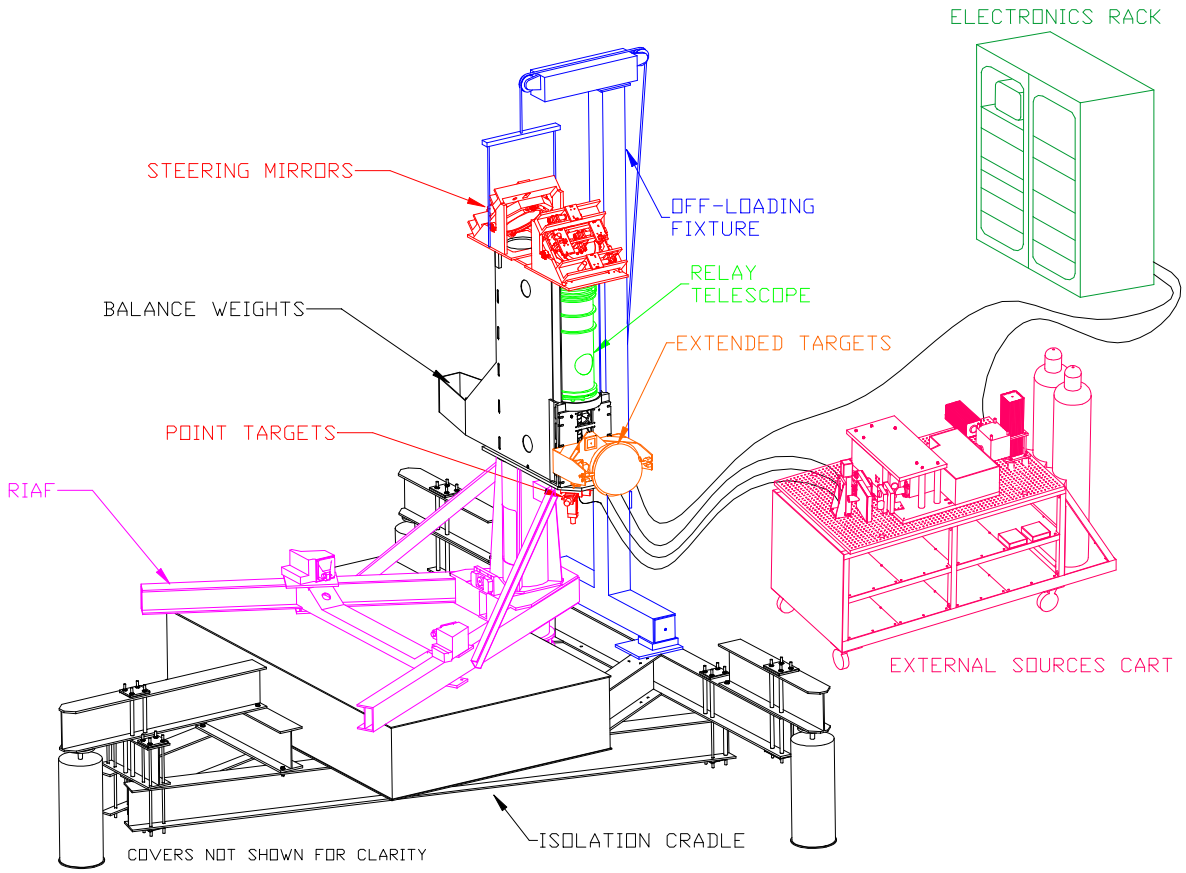
Optical Stimulus Has Successfully Completed Thermal-Vac, Is Ready for I&T



Optical Stimulus / CASTLE



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WFC3 I&T Flow at GSFC

11/02 — Start Elec Integ. on Flt Enclosure

12/02 - 1/03 — Optical Assy Metrology & Testing

2/03 — Optical Assy Integration

3/03 — Complete Elec Integration

2-3/03 — Integrate Flight 1 UVIS & QUAL IR Detectors

4-5/03 — Performance Test

6/03 — Match Mate Fit Check

7/03 — EMI / EMC Test

7/03 — Magnetic Survey

8/03 — Early Vest Test, Metrology & HFMS fit check

9/03 — Install Flight 1 IR Detector

9/03 — Acoustic Test

10-12/03 — TB / TV and Calibration

1/04 — Mass Properties

1/04 — Deliver to HST

8/04 — WFC3 SMGT

7/03, 10/03, 9/04 — Crew Familiarizations

9/04 — Integrated SMGT

12/04 — Ship to KSC

2/05 — Launch

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Summary

- Nearly all subsystems have been completed.
- WFC3 program is poised to begin a thorough integration and test period at Goddard.
- We are eager to deliver a superb panchromatic camera to HST in Servicing Mission 4.